The text-book under review will doubtless remain a standard for many years. It may be too extensive to meet the wants of most institutions for a first course but it will probably be consulted by many teachers who prefer to place briefer treatments in the hands of their students. The high mathematical attainments of its authors are naturally reflected in many details of treatment, and inspire deserved confidence in the accuracy of the statements relating to matters of fundamental importance. The modern tendency towards the insertion of numerous historical notes in elementary textbooks on mathematics is not followed here.

It may be added that the authors state in a foot-note on page 177 that a tangent can not be defined as a line meeting the conic in a single point. The opposite view was recently expressed by Professor Cajori in an article published in *School Science and Mathematics,* volume 22, page 463, where the author tries to support an inaccurate statement found on page 163 of the second edition of his "History of Mathematics," 1919. It is here stated that Roberval "broke off from the ancient definition of a tangent as a straight line having only one point in common with a curve." It may also be noted here that some readers might question whether it should be said that a mathematical argument can be convincing without being conclusive, as is implied by the authors in a footnote appearing on page 180. In view of the extensive literature on Greek algebra the second paragraph of the Introduction is misleading.

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SPECIAL ARTICLES

WATER CULTURE EXPERIMENTATION

As a one-salt solution is the simplest possible salt solution, so the simplest growth media that can be devised for plants, provided they need but two elements at a time, should be the proper combination of one-salt solutions. Because green plants require at least seven salt elements, available to and absorbed through the roots, complete nutrient solutions having these elements present together are employed as the media in which the plants are grown. The use of at least three simple salts plus a trace of iron (added as a salt) is required to supply the growth media with the necessary elements.

The writer has recently grown wheat for a period of three months, which included the heading out stage of the plants, in a combination of single salt solutions of KNO_3, $CaSO_4$ and $MgHPO_4$ (each of .01 mol. concentration). The plants grown in these solutions were equal or comparable in their various features of growth, including that of total dry weight, to those of plants grown contemporaneously in complete well-balanced nutrient solutions prepared either with the above named salts or with other salts supplying the same elements.

The salts named appear to be the only three salts that can be used as a combination of three single salt solutions that permit of normal and undiminished growth of wheat. This is the conclusion arrived at from an investigation of culture tests using those salts singly as combinations of one-salt solutions that were outlined as combinations of three-salt solutions (complete nutrient solutions) in the Plan of Cooperative Research on the Salt Requirements of some Agricultural Plants.[1]

Because the mono-basic phosphates given in the plan were found to be too acid for these tests with single salt solution, the diabasic phosphates of calcium and magnesium were substituted for those of the respective monobasic phosphates. It appears, therefore, that by using the proper salts, wheat plants grow as well with only two nutriment elements present in the media at one time (exclusive of a trace of iron supplied at weekly intervals to all cultures) as they do in complete nutrient solutions.

The set of plants that made best growth, of those sets tested, as combinations of one-salt solutions named, were apportioned among the solutions as follows: four days continuously in KNO_3, one day in $CaSO_4$ and one day in

[1] See Plan of Cooperative Research on the Salt Requirements of Representative Agricultural Plants, prepared for a Special Committee of the Division of Biology and Agriculture of the National Research Council. B. E. Livingston, editor. Baltimore, 1919.

$MgHPO_4$. On the seventh day the plants were transferred back to KNO_3 and the above sequence continued. The plants were rinsed in distilled water with every change of culture from one solution to another. Whether this apportionment of exposure of culture to the several solutions would continue to be the best for the growth of wheat can not be stated until the plants have matured. It appears the best apportionment of exposure of the plants to the different solutions may vary, being not inconsiderably influenced by the aerial growth environment and by the nutrient requirements of the plant at different stages of growth.

Because of its simplicity, the method appears well adapted for investigation of these points as well as for instruction in the principles of plant nutrition. It should aid materially in throwing more light on the causative interrelations of the growth of plants and the composition of the growth media.

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A NOTE ON THE SPERMS OF VALLISNERIA

After trying for many years to secure favorable fixation of ovules of *Vallisneria spiralis* the writer recently succeeded in getting more fortunate material. Perhaps a few words, by way of preliminary publication, on the method and results may be of interest to workers in this field.

The ovules are borne numerously in the epigynous ovary surrounded by a mucilaginous substance which greatly retards the action of reagents and is but slowly dissolved by water. Cutting the ovary across permits one to squeeze out the contents which in their mass movement break off the ovules and carry them out. Several hours of washing in water are then necessary to free these ovules from their gelatinous matrix. In repeated earlier attempts it was found that all ovules having received pollen tubes completed their fertilization and double fertilization before killing agents penetrated to them. If pistils were killed *in toto* the pollen tubes running down their inner walls in the edge of the gelatin would be well fixed, but the interior ovules were invariably found in poor shape due to the influence of this slime.

Last year the writer modified the method by lowering the temperature of the water used in dissolving the mucilage from the expressed ovary content. The water was cooled by adding small pieces of ice, and the container was set in a larger vessel of iced water. It was hoped in this way to slow down or stop both growth and cyclosis and to hold all parts *in status quo* until killing was possible.

The results were very satisfactory. Sperms were found not only in the tip of pollen tube within the synergid but in all subsequent situations through to the completion of fertilization. Many points regarding the male cells of Vallisneria, previously left obscure through poor fixation, were cleared up by use of this material. A brief statement of findings is given below.

The sperms of *Vallisneria spiralis* maintain their integrity as male cells until the egg is reached. During the journey through the pollen tube they remain joined end to end and pass out of the tip of the tube together. The sperm that later fuses with the egg emerges from the tube as a cell and immediately flattens against the egg membrane. Many preparations showed the male nucleus with its definite mass of cytoplasm and bordering membrane pressed, as a complete cell, against the egg cyst. One would hardly expect to find, in fixed material, stages showing events at the moment the two cells break together, for the union would probably be completed quickly. But the two masses of cytoplasm must intermingle in some degree in fertilization and probably the male cytoplasm partly or wholly enters that of the egg. The male nucleus soon moves to the center and unites with the egg nucleus. There can be no doubt of the morphology of the sperm up to the time of its union with the egg,—they come together as complete cells.

The second sperm loses its cytoplasm soon after it emerges from the pollen tube. Its nucleus is often observed as a spherical body within a strand of protoplasm extending from the egg-apparatus to the polars. Its successive positions suggest that it is carried to the polars by movement of cytoplasm within the embryo-sac. The male nuclei of Vallisneria are never vermiform in the slightest degree nor